The Photon Vacuum System At The European XFEL

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Technical Design of the Photon Vacuum System:

The vacuum flight tube will be designed to guarantee an average pressure in the overall system of less than 1 x 10^{-6} mbar. For constantly evacuating the beamlines we use ion pumps of triode type. One advantage of this pump type is that they are also able to pump a small amount of noble gas which is used for the SASE3 gas attenuator and some diagnostic elements. The pressure at the ion pumps will be much better than 1 x 10^{-6} mbar to ensure their targeted lifetime of 80000 hours. At some locations at the beamline, near mirrors and gratings, we require even better vacuum pressure. Here we use non evaporable getter (NEG) pumps in addition to the ion pumps. All parts are made of vacuum compatible materials, mostly stainless steel 304L or 316L. All the used up components pass through a cleaning procedure before installation to eliminate any contamination with hydrocarbons, so that the sum of the partial pressures of masses from mass 45 on to at least mass 100 has to be less than 10^{-3} of the total pressure of the cleaned item. More details can be found in the UHV Guidelines for X-Ray Beam Transport Systems. The following three figures show an overview over the individual items of the photon vacuum system for each SASE beamline. The gas sections will host diagnostic hardware that is operated under a noble gas atmosphere and needs to be separated from the rest of the vacuum system by differential pumping units. To protect the mirrors and gratings from particle contamination we introduce a particle free area 30 m around the sensitive items. For maintenance this segment can be separated by gate valves. All vacuum parts in the particle free area will only be handled or assembled in local cleanrooms class ISO 5. To protect the mirrors and gratings from particle contamination caused by dust that could be present in the rest of the beamline DN100 fast safety flap valves (VAT, series 75) will be installed upstream the distribution mirrors. In the unlikely event of an air inrush due to a massive leak or a broken vacuum window, these valves close within milliseconds, followed by closing the gate valves in the affected branch. This procedure ensures that the mirrors are protected and only one instrument of the individual beamline is affected, while the other instruments remains operational. Provided the experimental need of an accurate attenuation up to 3 orders of magnitude of the beam intensity at SASE 3, a windowless gas attenuator has been designed. The working gas in the 15 m long attenuation path will be Nitrogen in a pressure range of 10^{-4} mbar to 15 mbar.

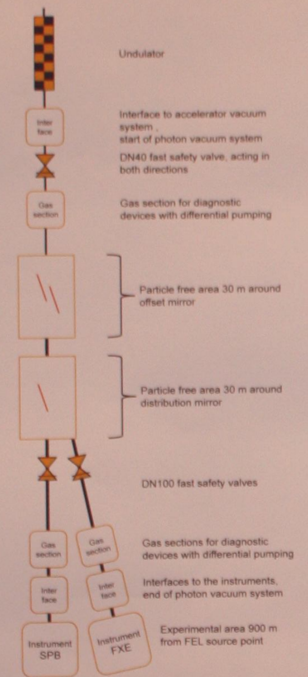

Figure 1: Overview SASE 1 photon vacuum system

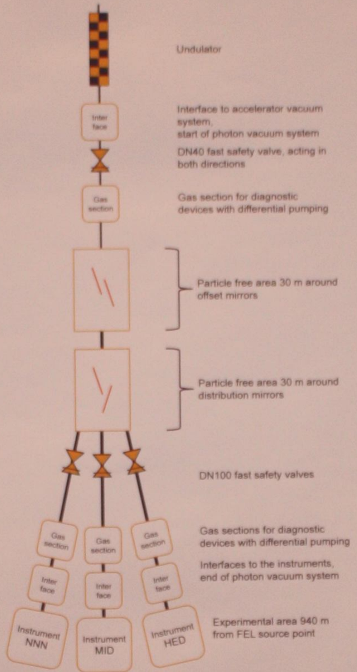

Figure 2: Overview SASE 2 photon vacuum system

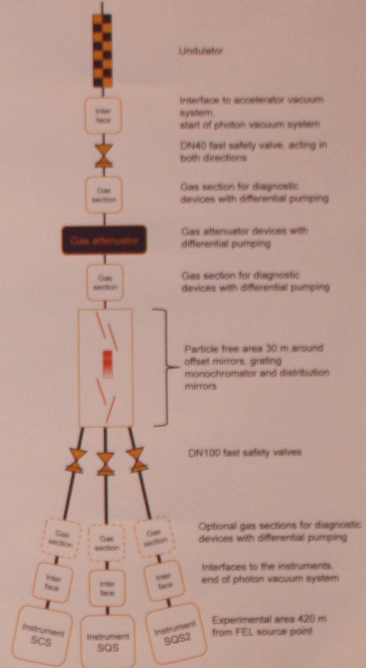

Figure 3: Overview SASE 3 photon vacuum system

SASE 3 gas attenuator

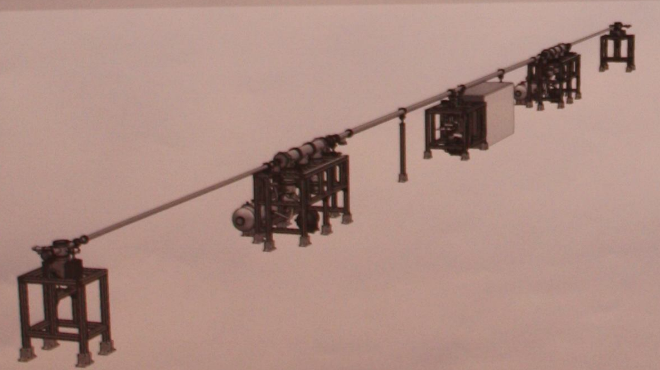

Figure 5: Model of SASE 3 gas attenuator.

For the development of the gas attenuator, some important constraints have been taken into account. First of all, the attenuation factor for the complete range of energies from 260 eV to 3,5 keV has been set to 10^3. The working gas pressure will be from 1 x 10^{-4} mbar up to 15 mbar, main gases used will be Nitrogen and, for some applications, Xenon. Other possibilities are Ne, Kr, Ar. The effective attenuation path is 15 m long, the aperture size at the differential pumping unit will be up to 25 mm to provide enough additional clearance to absorb possible misalignments of the beam. A maximum allowable pressure of 1 x 10^{-7} mbar after the last aperture has been set, in a way such that the transition upwards and downwards to the base pressure of the beamline (1 x 10^{-8} mbar) can be easily done with the inclusion of two respective ion pumps shown at both ends of the model.

Pressure distribution at mirror chambers

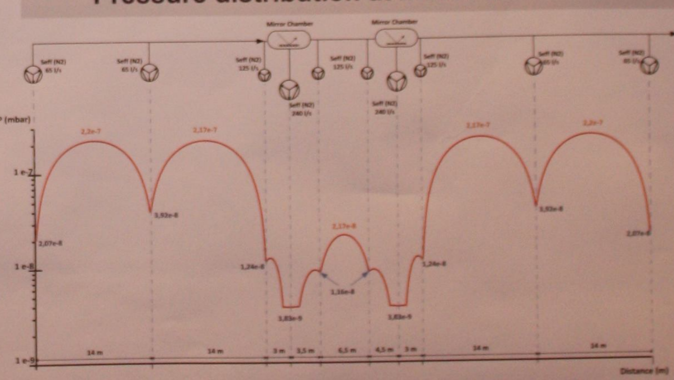

Figure 4: Pressure distribution at the mirror systems. Results from Calcvac software (M. Hoffmann, DESY).

Regarding to sustain the UHV condition in the mirror chambers, the pumping scheme shown in the Figure 4 has been foreseen. It contains a sequence of Ion Pumps with nominal pumping speed of 75, 150 and 300 l/s respectively. The estimated pressure profiles results from the following assumptions: S_{eff} = 85 % of S_N for all the pumps; 316L(N) stainless steel, mechanically polished; also a mild bake-out of the mirror chambers has been included (outgassing rates of 1 x 10^{-10} and 5 x 10^{-13} mbar·l/s·cm^2, respectively for the unbaked and baked surfaces). When using this scenario, it can be appreciated that a UHV pressure of 3,8 x 10^{-9} mbar can be achieved in the mirror chambers. Obviously, these results are consistent with the expected least performance of the vacuum system for the particle free area where the offset mirrors are.